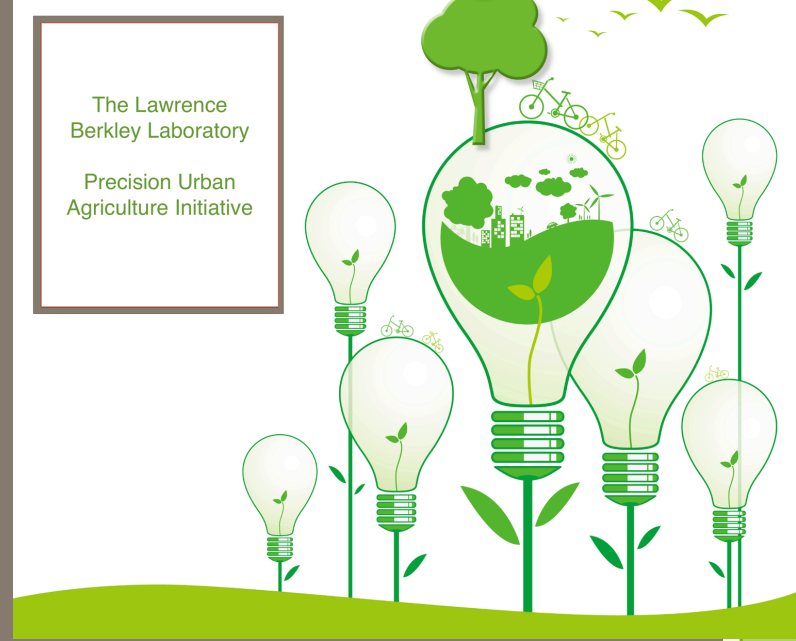




The Lawrence
Berkley Laboratory

Precision Urban
Agriculture Initiative



Breakthrough technologies to
Remake farming for modern
cities

LIGTT: An Introduction



Institute for Globally Transformative Technologies
at the Lawrence Berkeley National Lab

“Bringing Science Solutions to the World”

- 3,500 scientists & engineers
- \$800 million of annual R&D
- 13 Nobel Laureates
- Historically US-focused

“Bringing Science Solutions to the Developing World”

- Leverage LBNL’s unparalleled technology capabilities
- Rigorous ‘real-world’ product engineering
- Powerful partnerships with influential institutions and businesses around the world
- Innovative business models and funding mechanisms

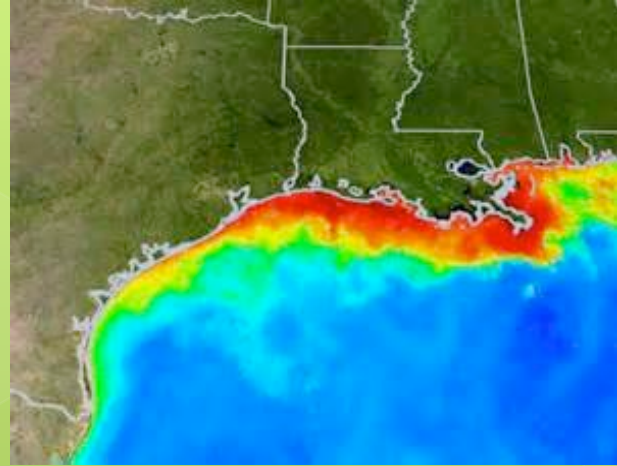
Water

- ◉ In the US irrigation accounts for 37% of freshwater withdrawals.
- ◉ In a state like CA agriculture accounts for 80% of water use.
- ◉ Intensive irrigation can waste as much as 40 percent of the water withdrawn.
- ◉ 44% of US streams and waterways are estimated to be impaired with agriculture the largest contributor



Fertilizer

- In the US we use of 60 million tons of fertilizer each year.
- Excess fertilizer pollutes streams and water ways and leads to algal blooms and dead zones in the Great Lakes and oceans



Pesticides

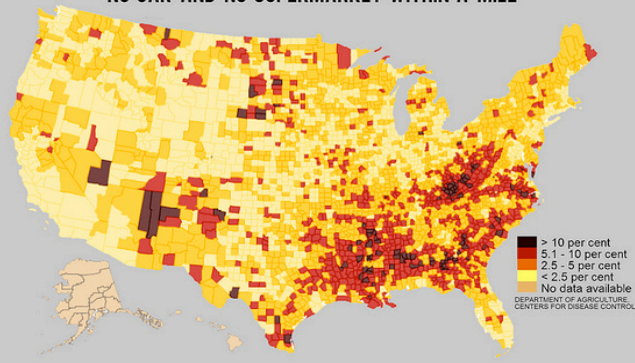
- In the US we use of 1 billion pounds of pesticides each year, with a cost of over \$12B dollars.
- 95 to 98% of pesticides reach a destination other than their target species.
- Pesticide use is associated with health problems for both consumers and farm workers as well as environmental damage





WHAT IS A "FOOD DESERT"?

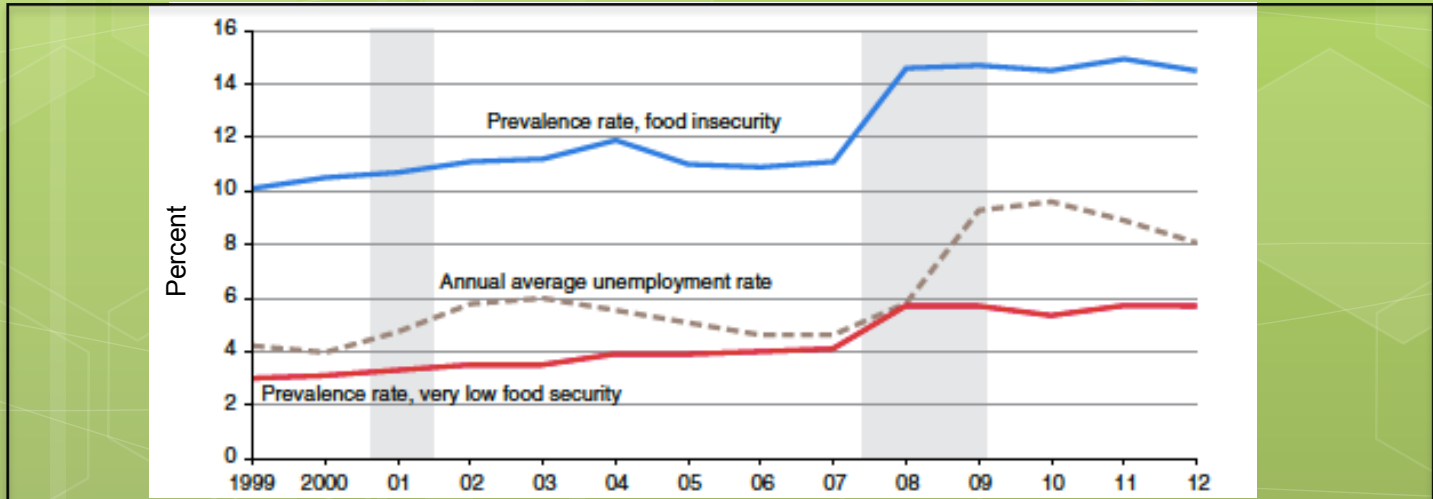
NO CAR AND NO SUPERMARKET WITHIN A MILE



Food insecurity in America: Core statistics

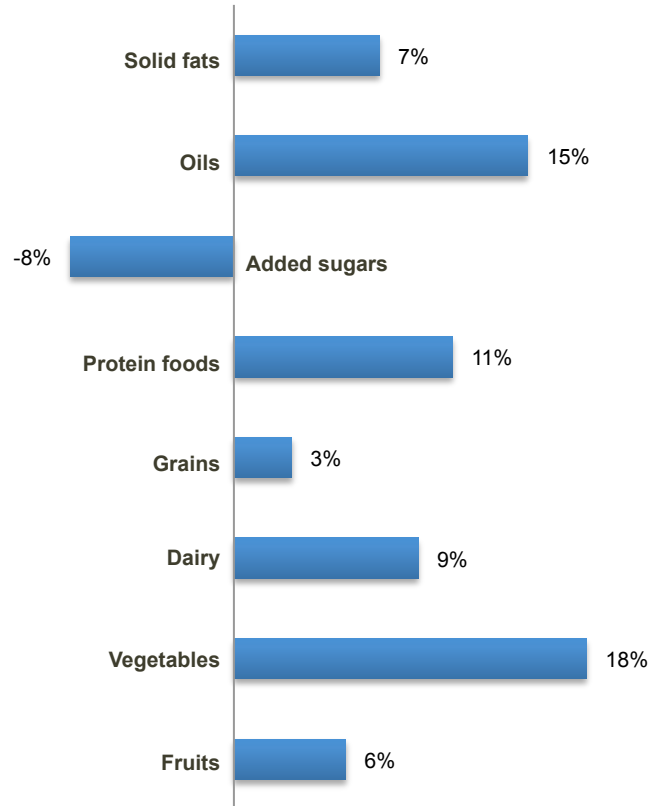
USDA Definitions	Low food security (aka Food insecurity without hunger)	<ul style="list-style-type: none">• Reports of reduced quality, variety, or desirability of diet• Little or no indication of reduced food intake
	Very low food security (aka Food insecurity with hunger)	<ul style="list-style-type: none">• Reports of multiple indications of disrupted eating patterns and reduced food intake

Prevalence of food insecurity and very low food security vs. national unemployment rate (1999-2012)



Food insecurity in America: Consumption patterns

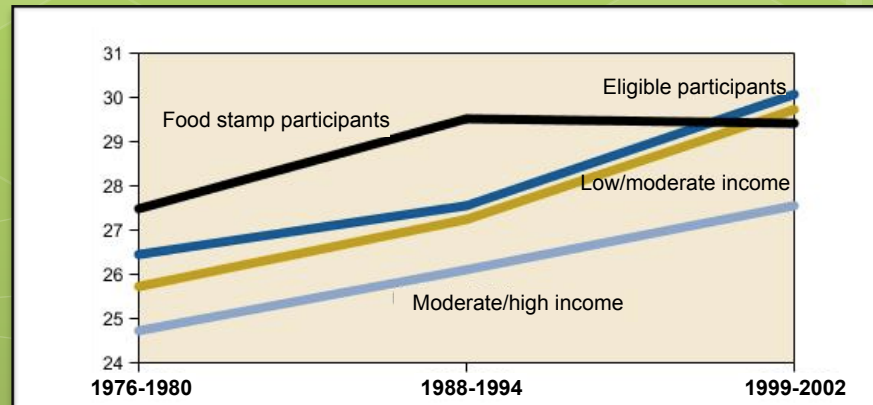
Food consumption gap, higher vs. lower income population



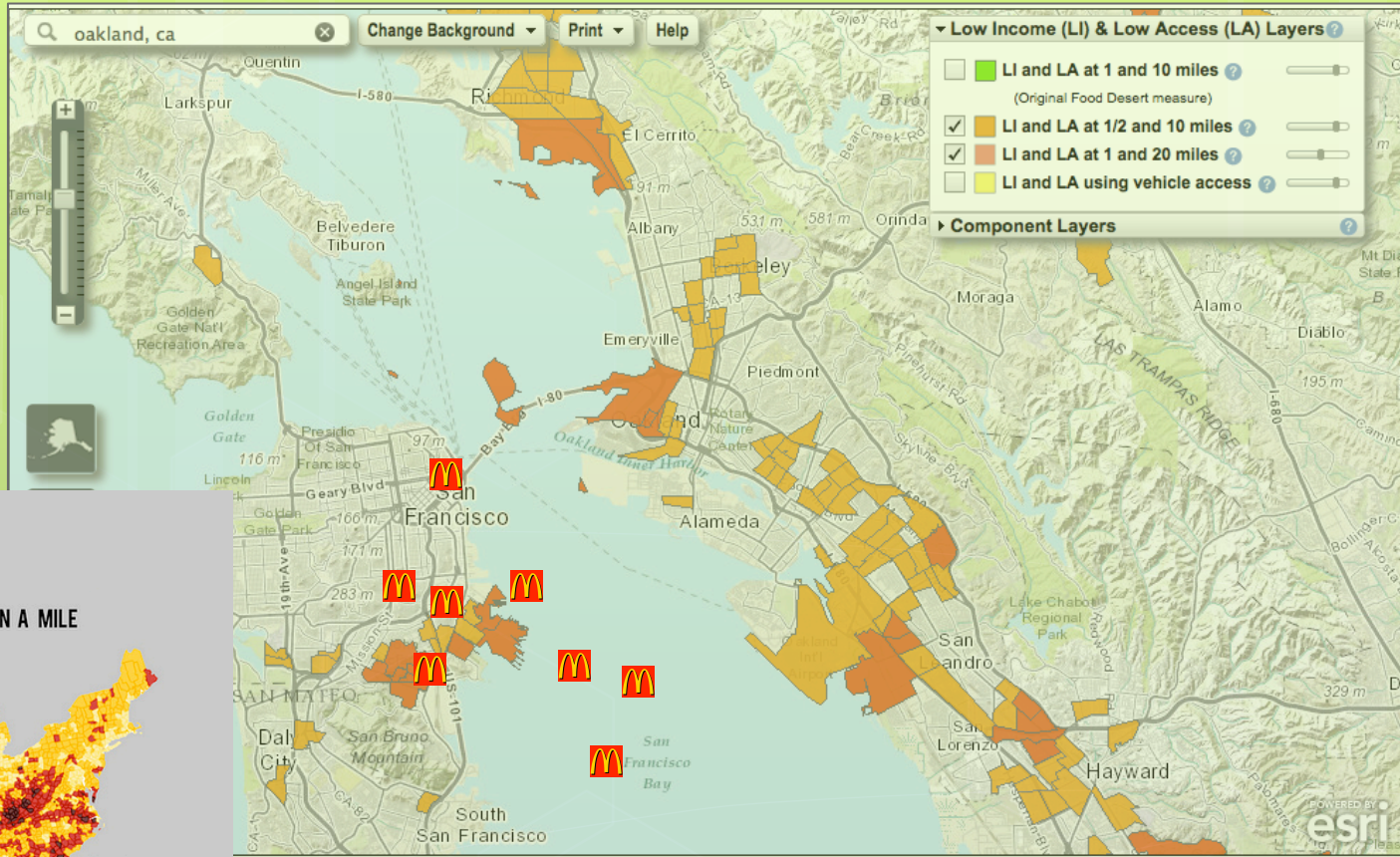
Percent of population that is obese, by income group



Convergence of obesity across income groups, BMI



WHAT IS A "FOOD DESERT"?



- Annual consumption 9,709,447 lbs.
- 151.6 Million gallons of water
- 20.6 tons of fertilizer
- 229 lbs. of pesticide
- 16,827 gallons of diesel fuel to transport
- 167.5 tons of CO₂ to transport

Feeding Oakland Lettuce





**What would it take to
grow
nutritious food...**

**Locally?
Sustainably?
Cost effectively?**

Precision Urban Agriculture

Targeted use of resources

- Sharply limiting use of water, nutrients, and space
- No pesticides, herbicides and insecticides

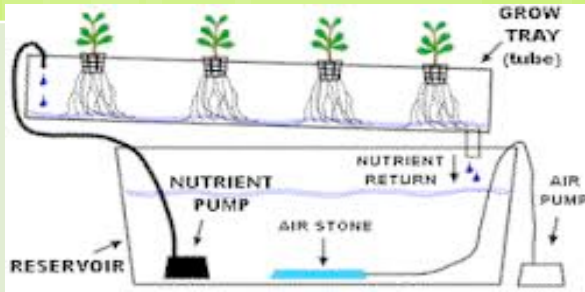
Environmental Controls

- Lighting
- Heating and cooling
- Air flow

Efficiencies in the production to consumer chain

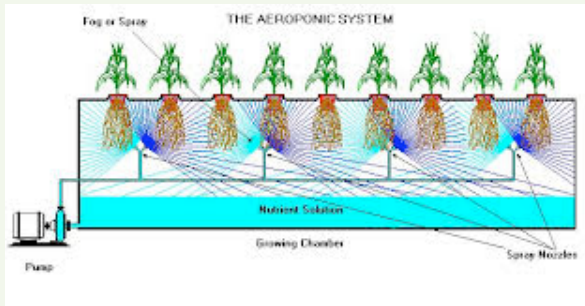
- Reduce waste in transportation and marketing
- On demand harvest
- Year round growing
- Efficient integration with urban scale users

New Growing Techniques



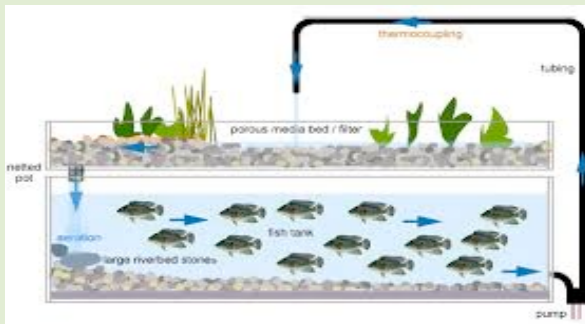
Hydroponics

- Plant roots grow in water
- 5-10% of the water
- No pesticides



Aeroponics

- Plant roots grow in air
- Nutrient and water mist
- 3-10% of the water
- No pesticides
- Faster growth cycles



Aquaponics

- Plants and food fish grown in a symbiotic biosystem
- 10-30% of the water
- No pesticides
- No fertilizer



Aerofarms, Newark, NJ

- 69,000 Sq/foot former factory
- Will produce 1.5M pounds of produce a year
- 5% of water use to traditional agriculture
- 70 jobs
- Enough produce to supply 60,000 people

Gotham Greens, Brooklyn, NY

- Hydroponic growing
- 15,000 Sq/foot rooftop greenhouse
- Produces 200,000 lbs of greens per year
- No pesticides, insecticides, or herbicides
- 5% of water use
- All electrical needs supplied by solar
- Gets heat and provides insulation to building below





Local Roots Farms, Los Angeles, CA

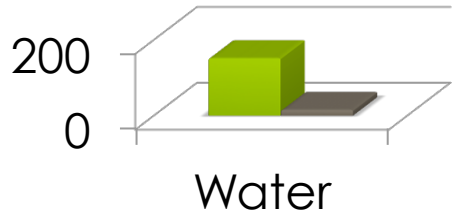
- 320 Sq/ft shipping containers produce up to 5,000 lbs leafy greens/month
- 1 container ~ 1 job
- No pesticides, insecticides, or herbicides
- 5% water usage of traditional agriculture
- Co-locate with customers to eliminate supply chain waste
- Just-in-time crop production



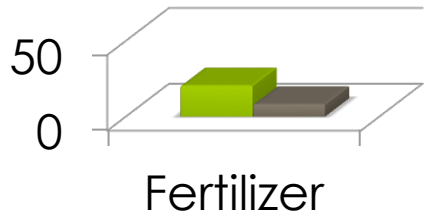
Sky Vegetables, Massachusetts and NY

- Partnership with NYC
- 8,000 SF farm on top of an affordable housing development
- Uses 10% of the water; water used is harvested rainwater
- Produces 130,000 lbs of vegetables a year
- Local hiring
- Full approach integrates solar, aquaculture and composting

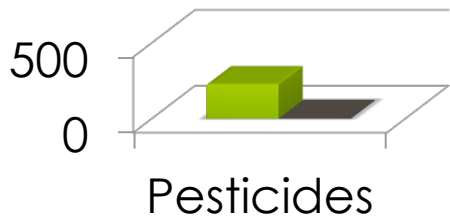
Feeding Oakland Lettuce



Savings = 136.44 Million Gallons

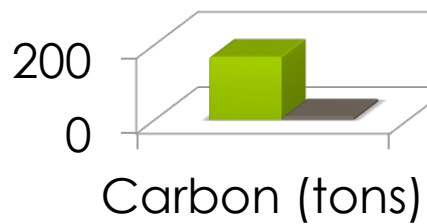
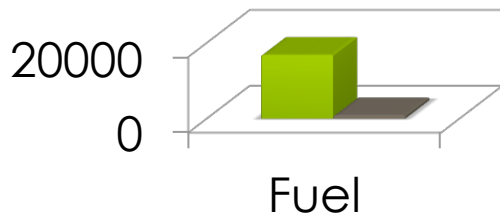


Savings = 12.36 Tons



Savings = 229 pounds

Feeding Oakland Lettuce



Savings = 15,986 Gallons

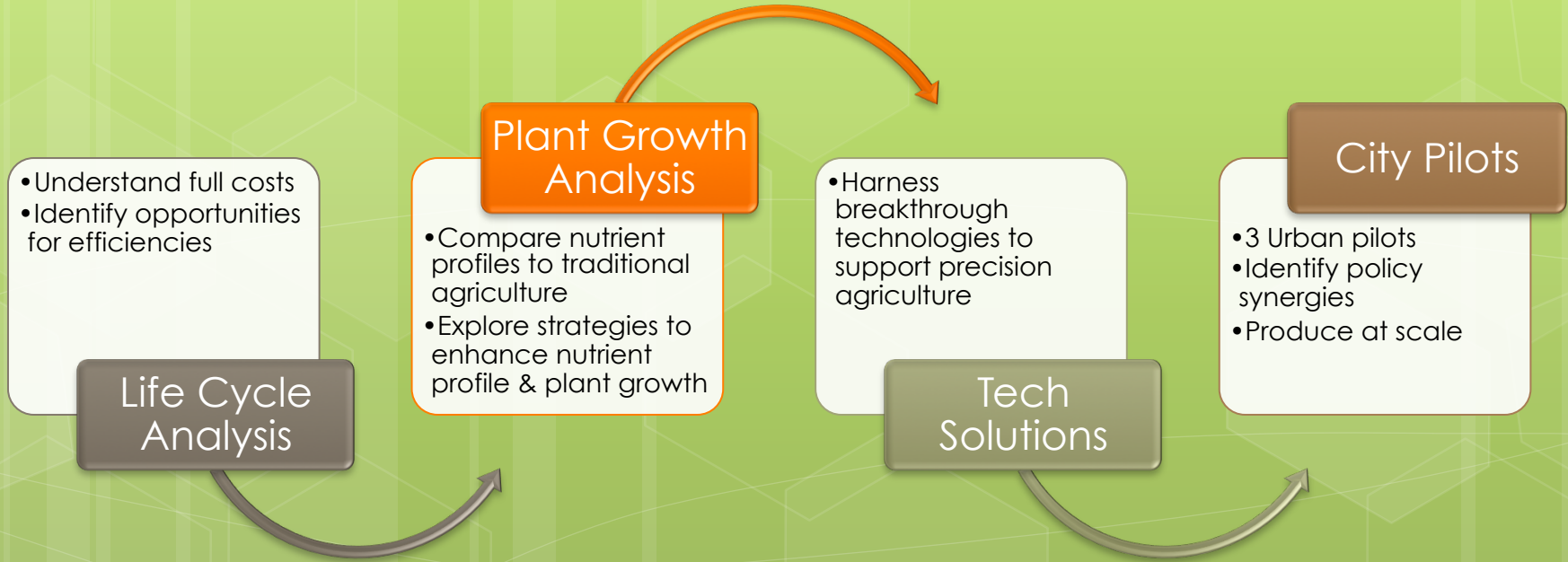
Savings = 159 Tons



What are the issues

- Cost competitiveness with traditional agriculture
- Ability to operate at scale
- Optimizing growing efficacy in a non-traditional environment

Four Stage Study



Life Cycle Analysis

- Understand full costs
- Identify opportunities for efficiencies

Life Cycle
Analysis



- Questions to be answered
 - What are the full costs of existing precision urban agriculture efforts and how do they compare to conventional agriculture
 - Given the current costs what are the opportunities for efficiency
 - What are the monetized environmental and other benefits—and how do they compare to conventional agriculture
- Study
 - Analyze figures from existing efficient growers

Understanding the state of the field

1. Critical review of existing scientific and technical literature

- Understand base-line conditions: cost and environmental footprint of conventional agriculture
- Status of existing and emerging technologies for precision urban agriculture
- Breakdown of main drivers of cost structure, energy use, resource use
- Identify and monetize indirect costs and impacts, e.g. pollution, erosion, water depletion

- Understand full costs
- Identify opportunities for efficiencies

Life Cycle
Analysis



2. Collect and analyze operational data from existing urban growers

- Compile and compare original data on production rates, economy, energy, resources, etc.
- Breakdown of main drivers of cost structure, energy use, resource use
- Identify similarities and differences between growers, to discern success factors
- Determine best practices for urban farming in different geographic/ environmental conditions

Plant Growth Analysis



Plant Growth Analysis

- Compare nutrient profiles to traditional agriculture
- Explore strategies to enhance nutrient profile & plant growth

- Questions to be answered
 - How do the nutrient and micro-nutrient profiles of plants grown without soil compare to those grown in traditional farming?
 - How do changes in lighting, nutrient delivery, seed coating, etc. impact plant growth, productive capacity and nutrient profile
- Study
 - Plant nutrient profiles based on samples from crops currently in production with existing growers
 - Use experimental units to collect data on how input changes impact plant growth and nutrient profile

Tech Solutions

• Harness breakthrough technologies to support precision agriculture

Tech Solutions



- Questions to be answered
 - What are the specific technological solutions that can be used to decrease costs, increase productivity, enhance nutritional value, or reduce environmental footprint of precision urban agriculture efforts?
- Study
 - Build test units on lab campus that will support experimentation around key aspects of precision urban ag systems.
 - Partner with innovative growers to test technological solutions in real world applications.

Tech Solutions

Problem: Optimizing Lighting

Solution space:

- Increased efficiency in LEDs,
- lighting recipes (variations in wavelength, strobe, pulse and daylight cycles to optimize growth),
- fiber optics for daylight harvest,
- nanotechnology for self-cleaning and condensation run off in greenhouse glass.

• Harness breakthrough technologies to support precision agriculture

Tech Solutions



Tech Solutions

Problem: Climate Control

• Harness breakthrough technologies to support precision agriculture

Tech Solutions



Solution space:

- Reduced excess heat from lighting,
- symbiotic heating and cooling with surrounding buildings,
- high efficiency greenhouse materials,
- heat exchanges,
- enhance uniform airflow distributions

Tech Solutions

Problem: Optimizing nutrient uptake

• Harness breakthrough technologies to support precision agriculture

Tech Solutions



Solution Space:

- Test how to support biome plant interaction in soilless growing
- Develop plant specific nutrient recipes
- Identify soluble organic nutrients appropriate to hydro, aero and aquaponic growing
- Test seed coatings and other mechanisms to promote efficient uptake

Tech Solutions

Problem: Efficient use of water

- Harness breakthrough technologies to support precision agriculture

Tech Solutions



Solution Space:

- Address issues with water recapture: Desalinization; nutrient rebalancing; sterilization; ion specific probes for water analysis
- Compare effectiveness of hydroponic and aeroponic technologies

City Pilots

City Pilots

- 3 Urban pilots
- Identify policy synergies
- Produce at scale

- Questions to be answered:
 - What are the policy; procurement and institutional relationships which will:
 - Ensure impact on low income urban populations
 - Optimize other beneficial impacts of the urban landscape (jobs, reinvestment, etc)
 - Ensure business viability for growers
- Study
 - Pilot initiatives in three urban centers

City Pilots

- Defined benefits and commitments from each partner
- Pilots in three cities (West Coast, Midwest, East Coast)
- Integrate precision agriculture into urban policy environment
- Implementation design to ensure food produced impacts health in food deserts



City Pilots

- 3 Urban pilots
- Identify policy synergies
- Produce at scale



- 3 Urban pilots
- Identify policy synergies
- Produce at scale

Commitments and benefits for urban partners

Commitments

- Help identifying and acquiring suitable space
- Shifts in zoning, regulations and tax policy to support urban farming
- Support negotiating electrical rates comparable to current farm rates
- Help build partnerships with key scale consumers reaching low income populations (schools, WIC, hospitals, etc.)
- Tie ins to other programs for the urban poor (jobs programs, efforts to impact healthy life styles, urban redevelopment, etc.)

Benefits

- Dedicated portion of production for partners and programs feeding the urban poor at an agreed upon price point.
- Job creation
- Secondary economic benefits to local economy
- Health impacts on urban communities

Commitments and benefits for growing partners

City Pilots

- 3 Urban pilots
- Identify policy synergies
- Produce at scale

Commitments

- Dedicate portion of production for partners and programs feeding the urban poor at an agreed upon price point.
- Local hiring

Benefits

- Help identifying and acquiring suitable space
- Shifts in zoning, regulations and tax policy to support urban farming
- Support negotiating electrical rates comparable to current farm rates
- Access to key scale consumers reaching low income populations (schools, WIC, hospitals, etc.)